

The Impact of Temperature and Relative Humidity Elevation on Mental Health of In-Patient Admitted Into Jos Teaching Hospital Jos, Plateau State, Nigeria

Jaiyeola O. Paul¹, Abdullahi Ayegba², Abimaje Okolo Suleiman¹

¹National Centre for Remote Sensing (NCRS), ²Engineering and Space Systems Department,

^{1,2}National Space Research and Development Agency, Jos, Abuja, Nigeria

ABSTRACT

The paper examined the impact of temperature and relative humidity escalation on mental health of in-patient admitted into Jos Teaching Hospital (JUTH Jos, Plateau State, Nigeria). The main independent variables of interest were temperature and relative humidity; we also employed two derived parameters (heat index and overlapping effect) in our analysis in which we used four years (2011-2014) data of psychiatric cases and in-patient that were admitted in the hospital, ex-post facto research design was adopted for the study. The population of the study comprised 2073 in-patient that was admitted in the hospital from the year 2011-2014 was sample used for the study. Data collected were analyzed with used of single regression and multiple regression analysis with complex heat index formula. The study found climate parameters (temperature and relative humidity) and their counterpart derived parameters (heat index and overlapping effect) make population vulnerable to the risk of psychiatric cases and do increase the numbers of patient admitted in the JUTH. There were positive association between the numbers of in-patient in the JUTH and those parameters with 41 and 38 critical/acute psychiatric cases due to overlapping and heat index effect respectively. In other word 79 (10.2%) of the total 778-numbers of patient traceable to those parameters were in critical/acute psychiatric condition. Increase in the relative humidity and overlapping made population more vulnerable to the risk of psychiatric cases with approximately equal strength than the heat index and temperature. But the heat index makes more risk than temperature. The vulnerability of population to psychiatric cases was not equally distributed throughout the year 2011-2014. Population response differently to the impact of each parameter throughout those years considered. The effective strength of relative humidity determines the effective strength of the overlapping effect and the effective strength of temperature determine that of the heat index.

How to cite this paper: Jaiyeola O. Paul | Abdullahi Ayegba | Abimaje Okolo Suleiman "The Impact of Temperature and Relative Humidity Elevation on Mental Health of In-Patient Admitted Into Jos Teaching Hospital Jos, Plateau State, Nigeria" Published in

International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-4 | Issue-2, February 2020, pp.125-136,

URL: www.ijtsrd.com/papers/ijtsrd29944.pdf



IJTSRD29944

Copyright © 2019 by author(s) and International Journal of Trend in Scientific Research and Development Journal. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0) (<http://creativecommons.org/licenses/by/4.0>)



KEYWORDS: Temperature, Relative Humidity, In-patient and psychiatric cases

1. Background to the Study

Temperature elevation and increase relative humidity which can as well lead to extreme heat event have significant effects on mental health and behavior. People with mental ill-health or already suffering from various psychiatric cases might aggravate to acute mental illness during extreme heat event (temperature and relative humidity elevations). People with mental illness and those who abuse substances are considered an especially vulnerable population to the impacts of extreme heat and other climate change-related events. Co-occurring variables such as poverty, substandard housing, and lack of access to cool environments all contribute to this increased vulnerability e.g. Homeless mentally ill people have little control over their environments and have very limited ability to protect themselves from heat exposures and therefore are at extreme risk (Crimmins *et al*, 2016). In the case of the people with preexisting mental health getting worse because of their vulnerability to the effects

of extreme weather events is due to the fact that the available mental services for the mental disorder people before the weather events are disrupted at the cause of extreme weather and this now make it difficult to treat them and even with newly emerge mental disorder patients i.e. both the older and the newly mental case will be remain untreated for long time and can worsening the case of the people with pre-existing mental health. The government, and various relief, and aid agencies and whole population must be pre-prepared by having all machinery put in place to deal with the mental (old and new) cases generated after the extreme weather events, because, even the countries which have well-established mental health services lack disaster preparedness to deal with the mental challenge posed after disaster (Wang *et al* 2008, Jull 1991, Morrissey 1995) e.g. During the Asian countries' response to Tsunami, mental health and psychosocial services received due to attention and

emergency mental health services were a part of the disaster emergency services (Ruzek, 2004)

There are profound associations between increasing rates of anxiety, depression, posttraumatic stress disorder, and even death and with increase in temperature.

Some review has been studied that shows association between temperature and mental illness or mental ill-health in the area of aggressive behavior, criminality, suicide events, performance in work place, cognitive, emotional expression, sleep and impairments of brain entropy functionality. The following are some the psychiatric case or mental ill-health linked with temperature elevations

- Elevated temperature increases the rate of aggressive behavior (**Anderson CA, 2001**)
- The rate of aggression and criminality has been associated with elevated temperature during the hot summer (**Haertzen C et al 1993, Cohn EG et al 2004**)
- The acts of suicide with violent has been observed with elevated temperature (**Maes M et al 1994, Linkowski P et al 1992, Lin HC 2008**). Both heat and drought amplified the risk of suicide and psychiatric hospital visits increases during hotter temperature (**Carleton TA2017, Hanigan I.C et al 2012, Burke M, et al 2018, Hansen A, et al 2008, Wang X et al 2014, Chan EY, et al 2018**)
- Temperature is one of the five factors such as Sound (noise, music), Temperature (heat, cold), air (pollution, freshness), light and color (sunlight, incandescent, fluorescent, windows, views), and space (density, arrangement of works station) of the workplace environment that can affect job performance (**Abdul R. A (2012)**). The alteration of the factor (temperature) can lead to improvement or decreasing of worker's performance. The temperature can alter human concentration and brain ability to coordinate necessary information for greater performance. Temperature as one of the climate change events or weather parameters can affect job performance, affect social relation and affect job satisfaction in an organization especially that is tasks demanding or complex (**Abdul R. A 20012**)
- High intensity level or prolonged exposure to heat as a result of elevated temperature can impaired our brain entropy functionality: delaying in the bran ability to process and to understand the number and predictability signals that is increasing with task complexity (**McCoy and Evan 2005**). This can cause total impairment of brain information entropy to reduce the uncertainty or the complexity in the signals or in the tasks to be performed.
- Weather parameters e.g. temperature influence other psychological phenomena, such as cognitive, emotional expression and sleep (**Obradovich N2017, Baylis P, et al (2018)**)
- Hotter temperature and added precipitation each worsen mental health (**Nick O et al (2018)**) especially those with pre-existing mental heat conditions and lower socioeconomic status are among the most vulnerable of those adverse environmental conditions.

- According to Robin (2018) Complex cognitive tasks such as working memory (spatial span test, pattern recognition) have been observed to be significantly impaired through heat stress and that increased heat also contributes to insomnia and worsens with increased humidity.
- Those patients that are more likely to experience heat stroke and other heat-related mental ill-health during escalation of temperature and humidity are those patients with severe psychotic or mood disorders, substance abuse disorders, and cognitive impairments (Robin, 2018) because they may have challenged during intense heat, and can lose their ability to make plans, have good judgment, and care effectively for themselves.

Heat has important implications for our mental health, potentially leading to increased emergency room visits, higher risk of death, and reduced emotional well-being. But extreme heat doesn't just worsen the *physical* health of people with mental health diagnoses; it can also exacerbate their existing *mental* health conditions (Juanita, 2017). And Juanita (2017 further narrated that a study in Toronto found that temperatures above 82 degrees Fahrenheit (28 degrees Celsius) were associated with increased rates of emergency room visits for mental health-related conditions, such as schizophrenia and mood disorders. Researchers in Quebec had a similar finding when they analyzed emergency department visits for "mental and psychosocial problems." As mean temperature increased, the number of these kinds of visits likewise increased. A recent state-wide study in California further reinforced this link. Researchers surveyed daily counts of mental-health related emergency room visits and found that more of these visits occurred during warmer days. Juanita (2017) stretch further that Extreme heat can actually make anyone feel worse—not just people with pre-existing mental health conditions. One study found that temperatures above 70 degrees Fahrenheit (21 degrees Celsius), decreased reports of positive emotions like joy or happiness, and increased reports of negative ones like stress or anger, when compared to average daily temperatures of 50 to 60 degrees Fahrenheit (10 to 16 degrees Celsius). Similarly, another study in Australia focusing on heat and humidity found that increases in humidity were associated with "high or very high distress." And according to one recent study, heat is even impacting our sleep. The researchers found that increased nighttime temperature was associated with increased occurrences of self-reported insufficient sleep. Generally, heat and humidity do scramble the brain / From Alice Bray, New York, NY, US.

According to David (2018) Results from previous research on associations between physiological-psychological mechanisms and high temperatures as well as brain temperature may provide more evidence to explain the assumption that exposure to heat/heat waves may trigger or exacerbate hospital admissions for mental health disorders among populations at risk in northern region of Vietnam," he writes. "However, further studies on biopsychology are needed to confirm the exact mechanism of high temperatures influence on neurotransmitters in treating mental disorders."

2. Methodology

Data were drawn from two sources been secondary data:

- Jos University Teaching Hospital (JUTH), Plateau State
- Meteorological data on temperature and relative humidity

The monthly and the yearly number of in-patient admitted with psychiatric cases or mental ill-health from the year 2011 to 2014 were collected from the JUTH hospitals was used for the study.

The meteorological data on temperature and relative humidity over Plateau state from 2011-2014 were retrieved from the Modern-Era retrospective analysis for Research Application, Version 2 (MERRA-2) web site. The mean meteorological data over Plateau state was using in assumption that the in-patient admitted into JUTH from year 2011-2014 comprises people with psychiatric all over the state.

Internet facility was employed for this research especially e-library to retrieve text books, journals, research papers etc. for an update information on the topic from others researchers and related studies e.g. Google Alerts and Google Trends to track comprehensive search over lengthy period.

The ex-post facto research design was adopted for the study and data collected were analyzed with used of single regression analysis, multiple regression analysis and with the complex formula of heat index analysis. Total number of in-patients admitted with mental ill-health from 2011-2014 into the hospital was 2073.

2.1. Method of Analysis

2.1.1. Heat Index (HI) and Overlapping Effects

However, it is not only ambient temperature that affects the performance of the brain, but also the level of ambient relative humidity, which may add an extra burden. The extra burden of the ambient relative humidity gives birth to heat, which might have great effects on mental health to cause ill-health. This is similar to Heat Index in nature, which did quantifies the combined effect of high temperature (or temperature) and relative humidity on human body that gives rise to apparent temperature commonly referred to as the heat index (HI) (Steadman 1979).

The simultaneous or corresponding increase in the ambient temperature and relative humidity can have great effects on human mental health and increase the rate of psychiatric cases and hospital visits. The heat index is known as apparent temperature is what the temperature feels like to the human body when the relative humidity is combined with the air temperature. Relative humidity also tends to compound the negative effects between hot weather and mental health

According to National Weather Services (<https://www.weather.gov/ama/heatindex>) there is direct relationship between the air temperature and relative humidity and the heat index, meaning as the air temperature and humidity increase (decrease), the heat index increases (decreases). Signify that the heat index effects will increase as the air temperature and humidity

increases and it has been shown in many literatures and which also confirmed in this study that the rate of hospital for psychiatric illness increases with increase in temperature and relative humidity. The numbers of psychiatric patients' visits hospital will then have positive association with increase in the heat index the extra burden of increase in the relative humidity. In this study we see it has crucial to study these two ambient factors together and to see their contributions in the numbers of psychiatric cases. Their contributions had been proved positive in increasing the numbers of psychiatric cases and the rate of hospital visits. The Heat index (HI) can be expressed as:

$$HI = c_1 + c_2T + c_3R + c_4TR + c_5T^2 + c_6R^2 + c_7T^2R + c_8TR^2 + c_9T^2R^2 \dots\dots\dots (1)$$

Where

T is the Ambient Temperature (in degree centigrade)

R is the Relative Humidity

- $c_1 = -8.78469475556$
- $c_2 = 1.61139411$
- $c_3 = 2.33854883889$
- $c_4 = -0.14611605$
- $c_5 = -0.012308094$
- $c_6 = -0.0164248277778$
- $c_7 = 0.002211732$
- $c_8 = 0.00072546$
- $c_9 = -0.000003582$

Now if we neglect higher power of 2 and multiplication of two parameters TR, equation (1) become multiple regression equivalent

$$HI = c_1 + c_2T + c_3R$$

This can be transformed to form

$$Y = a + b_1T + b_2R \dots\dots\dots (2)$$

So the prediction equation to minimize the sum of the square errors of prediction is

$$Y' = a + b_1T + b_2R$$

The R-square or coefficient of determination is the square of the correlation between Y and Y'.

Reducing equation (2) to only one parameter gives single regression analysis

$$Y = a + bT \text{ and } Y = a + bR \dots\dots\dots (3)$$

For the one variable case:

$$b = \frac{\sum TY}{\sum T^2} \text{ or } b = \frac{\sum RY}{\sum R^2}$$

$$a = \bar{Y} - b\bar{T} \text{ or } a = \bar{Y} - b\bar{R}$$

For the two variables case:

$$b_1 = \frac{(\sum R^2)(\sum TY) - (\sum TR)(\sum RY)}{(\sum T^2)(\sum R^2) - (\sum TR)^2}$$

And

$$b_2 = \frac{(\sum T^2)(\sum RY) - (\sum TR)(\sum TY)}{(\sum T^2)(\sum R^2) - (\sum TR)^2}$$

The equation for a, with two independent variables is:

$$a = \bar{Y} - b_1\bar{T} - b_2\bar{R}$$

Equation (1) was used to analyze the effect of heat index, equation (2) was used to analyze the overlapping effect of the two independent variables and equation (3) was used to analyze the effect of each parameter as separate independent variable. The result of the computation of the regression analysis was represented in graphical form.

From the graph we are able to determine the following:

- Coefficient of correlation between those parameters and the numbers of in-patient admitted with psychiatric cases
- Coefficient of Determination/ percentage of contribution to compute the total numbers of in-patient diagnosed with psychiatric cases and traceable/attribution to each of the parameters

The overlapping effect is simply mean how much variance in the numbers of in-patient with psychiatric cases is accounted for by the two independent variables, that is the important of the linear combination of the two parameters (temperature and Relative Humidity). The overlapping effect also signified that the two parameters have shared with each other as in the apparent temperature (heat index) which increases as the temperature and relative humidity increases and possibly shared the number of patient i.e. there is an intercept in their contribution in the number of patient. Here also the overlapping effects also signified that the two independent variables are correlated.

We should know also that the amount change in the numbers of patient admitted due to one parameter (say

temperature) while holding one constant (say relative humidity) is a function of the unique contribution of temperature. So, if one parameter (say temperature) overlaps considerably with other one (say relative humidity), then the change in the numbers of in-patient diagnosed with psychiatric cases (or mental ill-health) due to temperature while holding the relative humidity constant will be small. The following we happen if the two are varies without holding anyone constant:

- If one of the parameter has negative correlation with number of patient, the numbers of patient traceable/attribution to the overlapping effects will be smaller than sum of the contribution of the two parameters or small than the contribution of the parameter that have positive contribution when considered the two parameters separately as per the single regression analysis. Remember that the parameter with negative correlation contribute zero (or nothing) in the number of patients.
- If the two parameters have positive correlation with number of patients we expect the number of patient traceable/attribution to overlapping effects to be higher than the sum of the contribution of the two parameters when considered separately as per the single regression analysis or be higher than contribution from each parameters
- If both have negative contribution there shall be no overlapping attribute, the overlapping effect will be zero.

3. Data Presentation

3.1. TEMPERATURE AND RELATIVE HUMIDITY EFFECTS AS INDEPENDENT VARIABLES

Table1: PLATEAU STATE: Monthly and Yearly Number of In-Patient Admitted into JUTH, Temperature and Relative Humidity (2011-2014)

	2011			2012			2013			2014		
MONTH	2011 NUMB ER OF IN- PATIE NT	2011 TEMPERAT URE	2011 RELATI VE HUMID ITY	2012 NUMB ER OF IN- PATIE NT	2012 TEMPERAT URE	2012 RELATI VE HUMID ITY	2013 NUMB ER OF IN- PATIE NT	2013 TEMPERAT URE	2013 RELATI VE HUMID ITY	2014 NUMB ER OF IN- PATIE NT	2014 TEMPERAT URE	2014 RELATI VE HUMID ITY
JAN	17	24.53	19.85	45.00	25.67	20.02	48.00	26.02	31.18	52.00	26.71	16.87
FEB	31	28.85	33.07	44.00	28.75	23.73	36.00	28.46	26.70	41.00	28.38	15.95
MARH	20	30.04	26.26	54.00	29.47	16.90	42.00	29.90	48.61	48.00	29.60	37.28
APRIL	43	29.93	41.76	60.00	29.41	55.13	57.00	28.97	54.17	40.00	28.61	56.78
MAY	51	27.05	70.47	42.00	27.09	66.68	46.00	27.59	65.32	48.00	27.42	67.88
JUNE	46	25.81	75.89	55.00	25.16	77.09	43.00	26.44	68.84	46.00	26.10	75.25
JULY	67	25.21	75.48	50.00	23.88	83.53	53.00	25.30	73.08	8.00	25.41	75.75
AUGUST	49	24.14	81.91	53.00	23.48	85.62	50.00	24.33	77.99	21.00	24.13	81.38
SEPTEMBER	52	23.97	83.23	47.00	23.76	85.05	56.00	25.06	75.28	50.00	24.48	79.77
OCTOMBER	40	25.03	76.30	57.00	24.84	81.22	33.00	26.04	62.49	45.00	26.01	69.36
NOVEMBER	54	24.60	42.00	41.00	24.73	61.91	55.00	27.22	38.93	6.00	26.79	45.57
DECEMBER	51	23.92	22.18	45.00	23.32	36.35	35.00	26.42	29.57	0.00	25.89	21.06
	521			593.00			554.00			405.00		

Table2: PLATEAU STATE: Coefficient of Determination, % of Determination and Number of In-Patients Diagnosed and Traceable/Attributed to Elevated Temperature and Relative Humidity

Year	PLATEAU												Sum of In-patient from the Two Parameters
	Coefficient of Determination (R^2)	Coefficient of Correlation (r)	% of Determination	Strength of the Correlation	Number of In-Patient	Numbers of In-Patient Attributed to increase Relative Humidity Yearly	Coefficient of Determination (R^2)	Coefficient of Correlation (r)	% of Determination	Strength of the Correlation	Number of In-Patient	Numbers of In-Patient Attributed to increase Temperature yearly	
2011	0.3757	0.612943717	37.57	Positively moderate	521	196	0.1873	-0.4327817	18.73	Negatively moderate	521	(-) 98	196
2012	0.0625	0.25	6.25	positively very weak	593	37	0.047	0.216794834	4.7	positively weak	593	28	65
2013	0.1456	0.381575681	14.56	positively very weak	554	81	0.0271	-0.164620776	2.71	Negatively very weak	554	(-) 15	81
2014	0.0034	0.058309519	0.34	positively very weak	405	1	0.1082	0.328937684	10.82	Positively Moderate	405	44	45
					2073	315					2073	72	387

3.2. Heat Index (HI)**Table5: Coefficient of Determination, % of Determination and Number of In-Patients Diagnosed and Traceable/Attributed to Heat Index**

Year	PLATEAU					
	Coefficient of Determination (R^2)	Coefficient of Correlation (r)	% of Determination	Strength of the Correlation	Number of In-Patient	Numbers of In-Patient Attributed to increase Heat Index (HI) Per Yearly
2011	0.0377	-0.194164878	3.77	Negatively moderate	521	(-) 20
2012	0.0469	0.216564078	4.69	positively weak	593	28
2013	0.0001	-0.01	0.01	Negatively very weak	554	(-) 0
2014	0.1333	0.365102725	13.33	Positively Moderate	405	54
					2073	82

Table6: Coefficient of Determination, % of Determination and Number of In-Patients Diagnosed and Traceable/Attributed to Overlapping Effect of the two Independent Variables

Year	PLATEAU					
	Coefficient of Determination (R^2)	Coefficient of Correlation (r)	% of Determination	Strength of the Correlation	Number of In-Patient	Numbers of In-Patient Attributed to increase Overlapping Effect Yearly
2011	0.2979	0.545802162	29.79	Positively moderate	521	155
2012	0.1224	0.349857114	12.24	positively weak	593	73
2013	0.1434	0.378681925	14.34	positively weak	554	79
2014	0.0166	0.128840987	1.66	positively Very weak	405	7
					2073	314

4. Data Analysis

From table (1-6) shows the percentage contribution of the two main climate parameters (temperature and relative humidity) and two derived parameters (heat index and overlapping effect) in the total number of psychiatric in-patients and to know the extent to which increase in the mental health-illness associated with increase in:

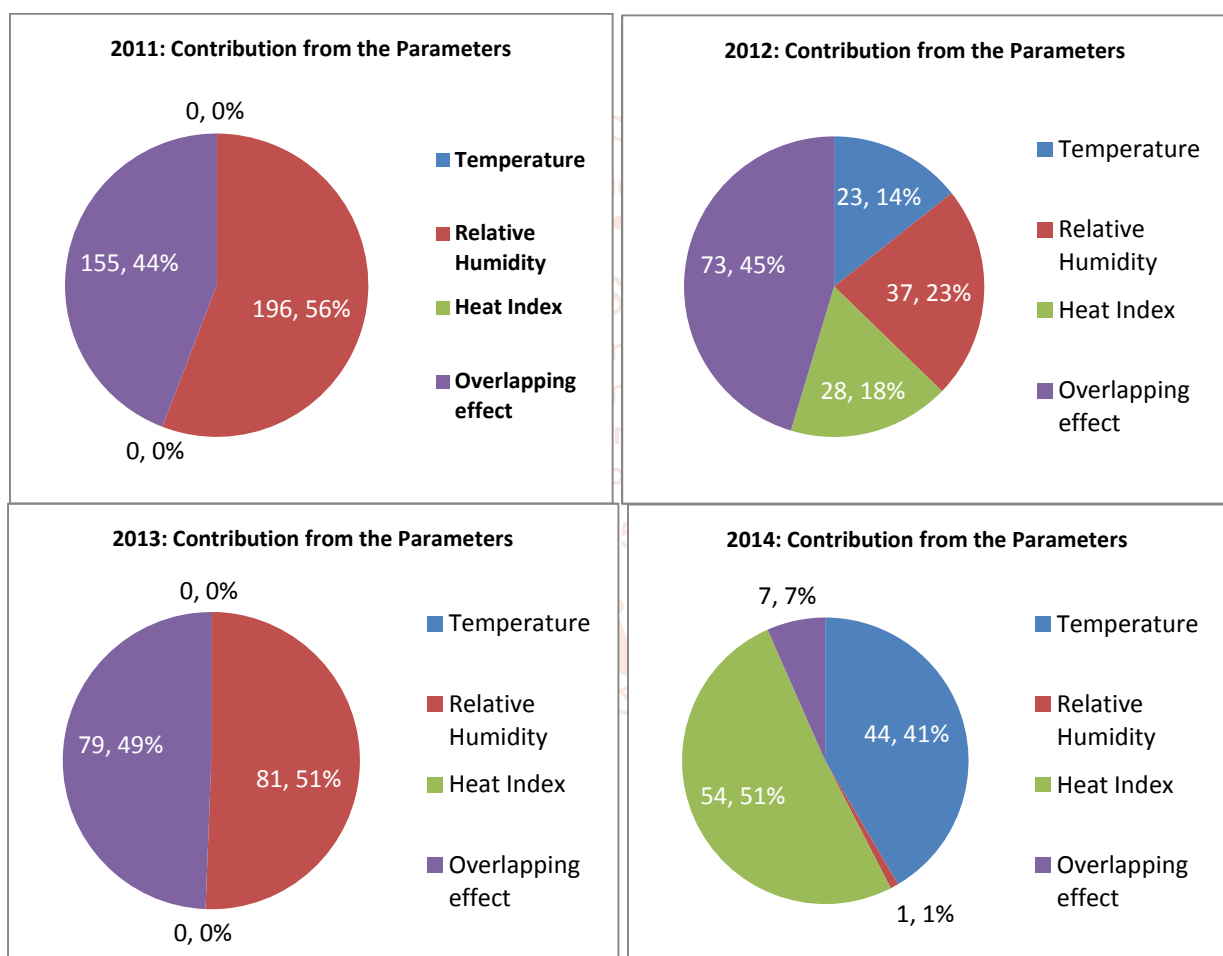
- Relative Humidity
- Temperature
- Heat Index (HI)
- Overlapping effect of the two independent variables

This was done from the rate at which numbers of patient visited the hospital yearly or monthly from 2011-2014

The percentage increase or decrease depends on whether the correlation coefficient is positive or negative. If it is positive, meaning that the numbers of psychiatric patients increases with increase in those parameters. If it is negative, simply mean that the number of patients decreases with increase in those parameters. The positive simply means that the mental ill-health is traceable to the parameters while the negative means that the mental ill-health is not traceable to the parameters

With these we are able to establish the strength of the independent variables by examining their correlation with numbers of patient with mental illness through regressions analysis.

- Positive contribution simply means positive associations (correlation) between the numbers of psychiatric in-patients and the increase in those parameters. The numbers of psychiatric patients increases with increase in the parameters. Here we have numbers of patient that were diagnosed and found positive with mental ill-health and traceable to the increase in the parameters
- Negative contribution means negative associations (correlation) between the numbers of psychiatric patients and the increase in those parameters. The numbers of psychiatric patients decreases with increase in the two parameters. Here we have numbers of patient that were diagnosed and found negative with mental ill-health and not traceable to the increase in the parameters
- All negative contribution will be taken has zero contribution. It makes no contribution to number of patient admitted into hospital from 2011-2014.



- In the year 2011, the two parameters that made population to be more vulnerable to the risk of psychiatric cases were the increase relative humidity and overlapping effect. But relative humidity made population more vulnerable than the overlapping effect. No psychiatric cases were traceable to temperature and heat index effect.
- In the year 2012, both the main parameters and the derived parameters have positive association with numbers of patient admitted. The overlapping effect made population more vulnerable to the risk of psychiatric cases than the others parameters, followed by: Relative humidity, heat index and temperature in that order.
- In the year 2013, the two parameters that made population to be more vulnerable to the risk of psychiatric cases were the increase relative humidity and overlapping effect. But relative humidity made population more vulnerable than the overlapping effect. No psychiatric cases were traceable to temperature and heat index effect.
- In the year 2014, both the main parameters and the derived parameters have positive association with numbers of patient admitted. The heat index effect made population more vulnerable to the risk of psychiatric cases than the others parameters, followed by: Temperature, overlapping effect and Relative humidity in that order.

5. Discussion of Findings

Table7: Summary of the Analysis

	PLATEAU					
Year	Temperature Contribution	Relative Humidity Contribution	Heat Index (HI) Contribution	Overlapping Effect Contribution	Number of In-Patient	Total Numbers of In-Patients Attributed to those Parameters
2011	(-) 98	196	(-) 20	155	521	351
2012	23	37	28	73	593	161
2013	(-) 15	81	(-) 0	79	554	160
2014	44	1	54	7	405	106
	67	315	82	314	2073	778

5.1. The Controllability of Relative Humidity over the Overlapping Effect

In this study it was discovered that the contribution from relative humidity have profound effect on the overlapping effect. The observations were as follow:

- When increase the relative humidity has positive association with the number of the in-patient with psychiatric cases or mental ill-health, the increase overlapping effect will also has positive association with the number of patients even when increase in temperature has either positive or negative association with number of patients admitted e.g. 2011&2012 or 2013&2014
- In a situation where the increase relative humidity has positive contribution and the temperature elevation has negative contribution in the number of patient, it was discovered that the positive contribution from the overlapping effect will fall below that of the relative humidity e.g. 2011 and 2013
- In a situation where the increase relative humidity and temperature elevation have positive contribution in the number of patient and the increase in the relative humidity has higher contribution, it was discovered that the positive contribution from the overlapping effect will be higher than that of the relative humidity also higher than the sum of the contribution from the two parameters e.g. 2012
- In a situation where the increase relative humidity and temperature elevation have positive contribution in the number of patient while the increase in the relative humidity has lower contribution than the contribution from temperature elevations, it was discovered that the positive contribution from the overlapping effect will be lower than the contribution from both parameters e.g. 2014

The trend, at which increase in the relative humidity made population vulnerable to the risk of psychiatric cases /mental illness from 2011-2014 is the same with the trend of the overlapping effect e.g. their contribution fell from 2011 to 2012, rose again from 2012 to 2013 and fell in 2014

In overall total contribution from 2011-2014, the contribution (315 numbers of patients) from the increase in the relative humidity is approximately equivalent to the contribution (314 numbers of patients) from overlapping effect just within rounding error.

5.2. The Controllability of Temperature over the Heat Index Effect

In this study it was discovered that the contribution from temperature has profound effect on the heat index effect. The observations were as follow:

When increase the temperature has positive association with the number of the in-patient with psychiatric cases or mental cases, the increase in the heat index effect will also has positive association with the number of patients even when increase in relative humidity has either positive or negative association with number of patients admitted e.g. 2012 & 2014

In a situation where the increase temperature has negative contribution and the increase relative humidity has positive contribution in the number of patient, it was discovered that the contribution from the heat index effect will be negative e.g. 2011 & 2013

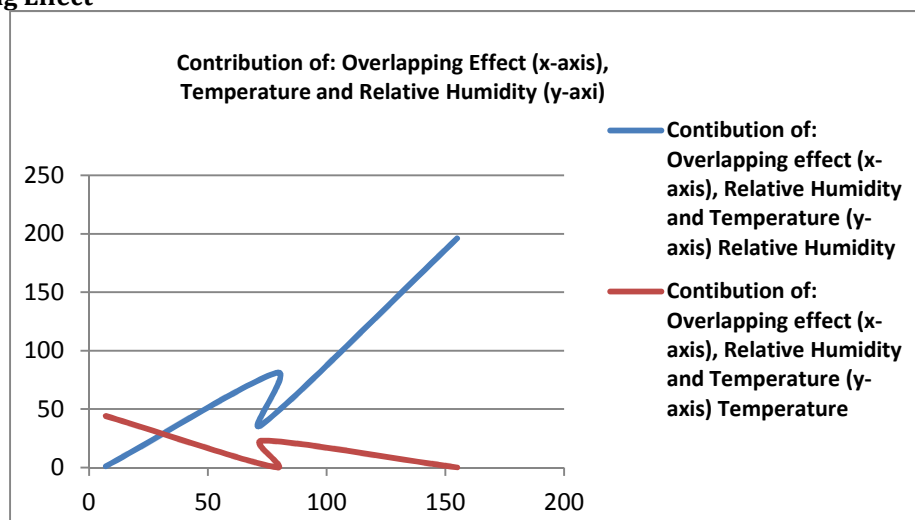
In a situation where the increase relative humidity and temperature elevation have positive contribution in the number of patient and the increase in the relative humidity has higher contribution, it was discovered that the positive contribution from the heat index effect will be higher than that of the temperature, but lower than the contribution due to increase in the relative humidity and also lower than the sum of the contribution from the two parameters e.g. 2012 *

In a situation where the increase temperature and temperature elevation have positive contribution in the number of patient and the increase in the relative humidity has lower contribution than the contribution from temperature elevations, it was discovered that the positive contribution from the heat index effect will be higher than the contribution from both parameters e.g. 2014.

The trend, at which increase in the relative humidity made population vulnerable to the risk of psychiatric cases /mental illness from 2011-2014, is the same with the trend of the heat index effect e.g. their contribution rose from 2011 to 2012 fell again from 2012-2013 and rose in 2014

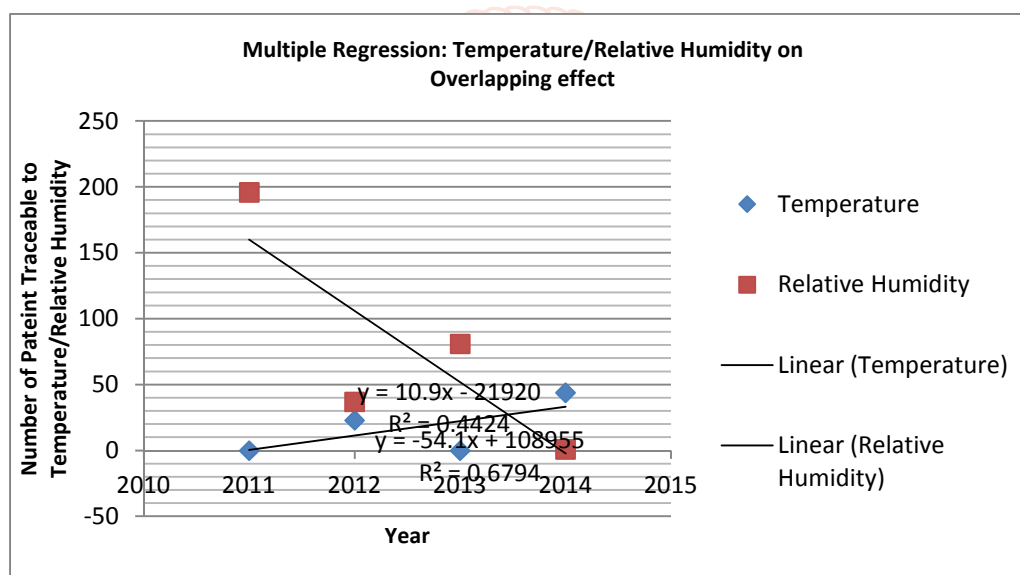
5.3. Critical Psychiatric Condition

5.3.1. Overlapping Effect

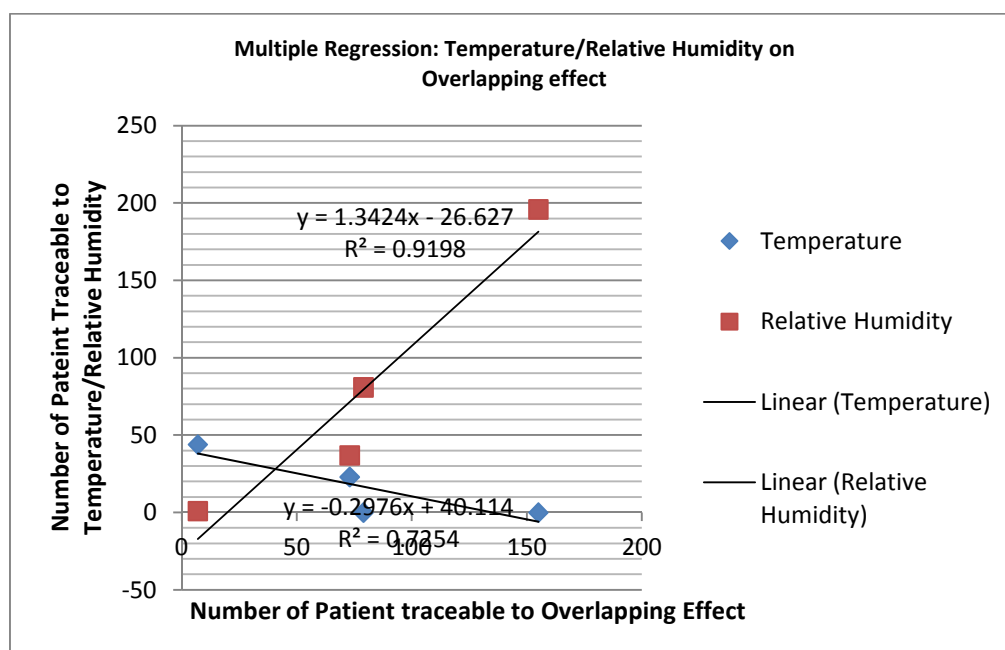


Graph1: Contribution of: Overlapping Effect (x-axis), Temperature and Relative Humidity (y-axis)

The crossing is an indication of overlapping effect of the contribution from the increase in the relative humidity and temperature.



Graph 2: Contribution of: Years (x-axis), Temperature and Relative Humidity (y-axis) Relationship



Graph3: Contribution of: Overlapping Effect (x-axis), Temperature and Relative Humidity (y-axis)

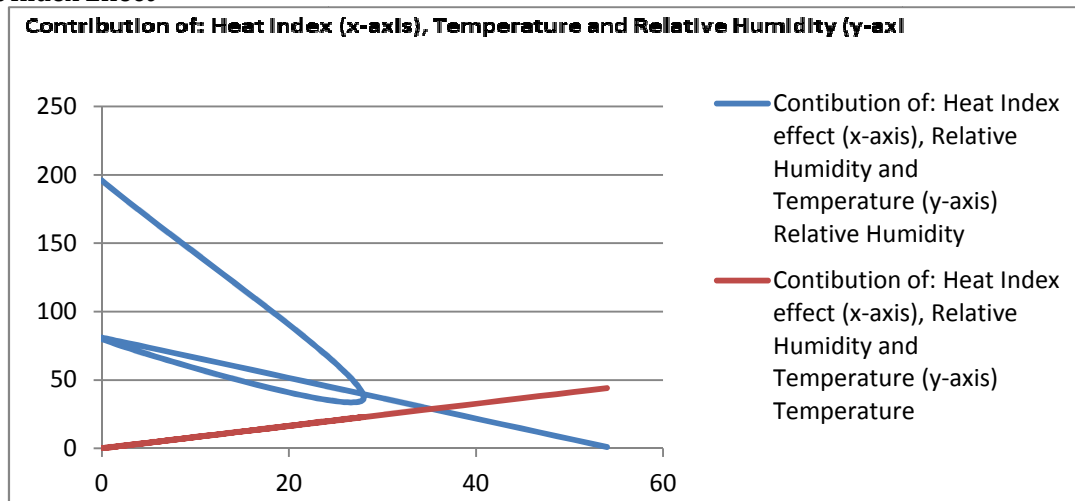
From Graph 3: At the Intercept

- The contribution of the overlapping effect equals 41-number of in patients diagnosed with psychiatric cases and traceable to overlapping effect
- The increase in temperature and relative humidity have equal contribution of 28-number of in-patients.

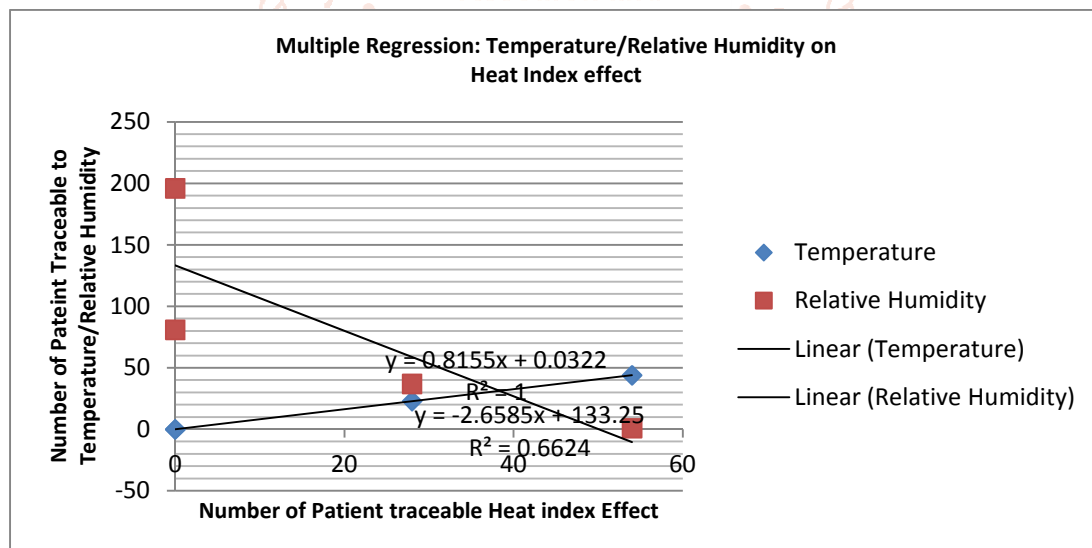
$$\sqrt{28_T^2 + 28_{RH}^2} \approx 40$$

- This is equivalent to the 41-number of patient traceable to Overlapping effect within rounding errors. The overlapping effect at the intercept can also be referred to as Resultant Effect of the two climate parameter at the intercept.
- At this point we can say 41-number of patient admitted from the year 2011 to 2014 were in a critical condition than other in-patient admitted due to overlapping effect contributed by the increase in temperature and relative humidity.

The three graphs (1-3) also show profound relationship between Relative humidity and temperature: in that the Temperature is inversely proportional to the relative humidity.

5.3.2. Heat Index Effect

Graph4: Contribution of: Overlapping Effect (x-axis), Temperature and Relative Humidity (y-axis)



Graph5 (linear): Contribution of: Heat Index Effect (x-axis), Temperature and Relative Humidity (axis)

From Graph 5: At the Intercept

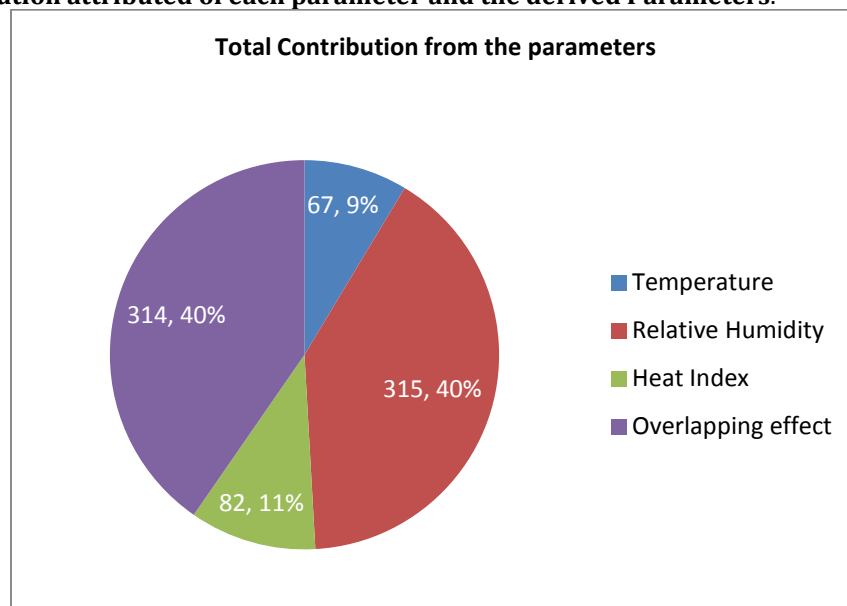
- The contribution of the heat index effect equals 38-number of in patients diagnosed with psychiatric cases and traceable to the increase in the Heat Index effect
- The increase in temperature and relative humidity have equal contribution of 32-number of in-patient.
- At this point we can say 38-number of patient admitted from the year 2011 to 2014 were in a critical condition than other in-patient admitted due to the increase in the heat index effect as the temperature and relative humidity increases simultaneously.

Here we cannot be talking of **Resultant Effect** of the two climate parameter at the intercept because the equation of the heat index is non-linear complex equation (equation 1) while equation (2) is linear equation for the overlapping effect also called **Linear Multiple Regressions Equation** for the two climate parameters (temperature and relative humidity) as the two independent variables of interest.

5.3.3. Summary of Discussion of Findings

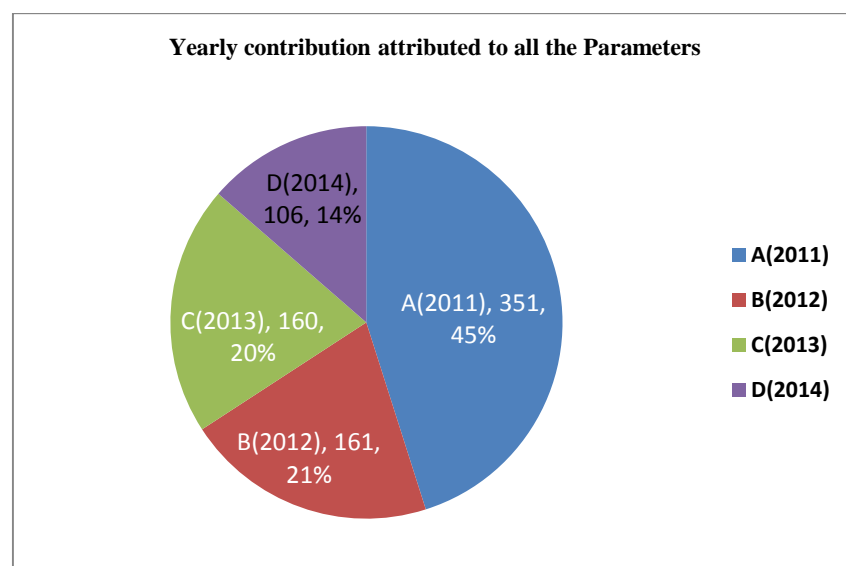
- The trend of impact of Relative Humidity on numbers of patient is the same with the trend of the overlapping effect and the strength of the overlapping effect is been determine by the relative humidity
- The trend of impact of Temperature on the numbers of patient is the same with the trend of heat index and the strength of the heat index is been determine by the temperature.
- At critical point of overlapping effect the overlapping effect contributed 41-numbers of patient that has critical/acute psychiatric cases out of total of 314-numbers of patients attributed to overlapping effect in 2011-2014 and at this point the temperature and relative humidity contributed equals value of 28-numbers of patient. The 41-number of patient with acute psychiatric cases is equivalent 40-numbers of patient;the resultant effect of the 28-numbers of patient contributed each by the temperature and relative humidity at the critical point or at intercept. (the equivalent is within random errors)
- At critical point of the heat index effect the heat index effect contributed 38-numbers of patient that has critical/acute psychiatric cases out of total of 82-numbers of patients attributed to heat index effect in 2011-2014 and at this point the temperature and relative humidity contributed equals value of 32-numbers of patient

5.3.3.1. Total Contribution attributed of each parameter and the derived Parameters.



Temperature and Relative humidity are the main climate parameter, while Heat index and Overlapping effect are the derived parameters derived from the value of temperature and Relative Humidity
Total number patient with psychiatric cases diagnosed and traceable/attribution to those parameters was 778-numbers of patient.

- Relative humidity and Overlapping effect contributed approximately 40% equally.
- Heat index contributed 11%
- Temperature contributed 9%



Population are affected psychiatrically and more vulnerable to the risk of psychiatric cases in the year 2011 than the others years. i.e. 45%, 21%, 20% and 14% in the year 2011, 2012, 2013 and 2014 respectively.

Out of 2073 total numbers of in-patient admitted with psychiatric in the 2011-2014, 778-numbers of patient were attributed to both main and derived parameters i.e. 37.53%. The remaining 1295 (62.47%) numbers of patient can attributed to others factors rather the four parameters that we considered.

- The increase in the relative humidity made Jos population to be vulnerable to the risk of psychiatric cases than temperature simply because The Jos been located on plateau in Plateau State nearly experience cold temperature over the year, probably high degree of air moisture. But Jos in Plateau State is of low/cold temperature region. Since warm high air is less dense than cold air, there is more room for water vapor in warm summer air/warm temperate region as compared with cold winter air/cold temperate region. It will take shorter time for air in Jos to reach saturation point.(i.e. air in Jos will quickly reach saturated point).. It is assumed that the ambient air enveloped Jos already contains more moisture, so that saturated can be quickly attainable in Jos than the surrounding state (i.e. colder air doesn't require as much moisture to become saturated as warmer air). With the same temperature and relative humidity, Jos will be more humid than the surrounding state and can hinder evaporation of heat from the skin of population in Jos and this can escalate brain heat (as relative humidity increases) due to internal heat generated due to increasing humidity. According to Ning D et al (2016) It well know and understand that perspiring is the body's primary physiological response to maintain core temperature when under heat stress, and that this process is inhibited in very humid conditions as the air approaches saturation point. Saturation air does not evaporate moisture from the skin surface very effectively, which reduces the efficiency of sweating to reduce the heat load. Thus, we could expect extreme heat to have worse effects on mental health when humidity is high.

This can be why the increase in the relative humidity increases psychiatric cases among Jos population than increase in temperature

6. Conclusion

Climate parameters (temperature and relative humidity) and their counterpart derived parameters (heat index and overlapping effect) make population vulnerable to the risk of psychiatric cases and do increase the numbers of patient admitted in the JUTH. There were positive associations between the numbers of in-patient in the JUTH and those parameters with 41 and 38 critical/acute psychiatric cases due to overlapping and heat index effect respectively. In other word 79 (10.2%) of the total 778-numbers of patient traceable to those parameters were in critical/acute psychiatric condition. Increase in the relative humidity and overlapping effect made population more vulnerable to the risk of psychiatric cases than the heat index and temperature simply due to the fact that ambient air enveloped Jos already contains more moisture, so that saturated can be quickly attainable in Jos than the surrounding state and can be facilitated by the increase in the relative humidity than increase in the temperature. Perspiration can be hinder at saturated point and this is inhibited in very humid conditions as the air approaches saturation point. Saturation air does not evaporate moisture from the skin surface very effectively, which reduces the efficiency of sweating to reduce the heat load. Lacking of sweating allow heat accumulations in the body which can escalate brain temperature thereby affect brain entropy. But the heat index makes more risk than temperature because the increase in the relative humidity compounded negative effect of increase in the temperature and then seen as heat index effect. The vulnerability of population to psychiatric cases was not equally distributed throughout the year 2011-2014. Population response differently to the impact of each parameter throughout the years considered. The effective strength of relative humidity determines the effective strength of the overlapping effect and the effective strength of temperature (line under the compounded effect of temperature from increase in the relative humidity) determine that of the heat index.

Reference

- [1] Abdul R. A (2012): A Theoretical Frame work and Analytical Discussion on Uncogential Physical
- [2] Anderson C. A. (2001): "Heat and violence," Current Directions in Psychological Science, vol.
- [3] 10, no. 1, pp. 33–38, 2001. View at Publisher • View at Google Scholar
- [4] Baylis, P. (2018): "Weather impacts expressed sentiment". PloS One 13:e0195750
- [5] Burke M, et al (2018): "Higher temperatures increase suicide rates in the United States and Mexico. Nat Clim Change 8:723–729
- [6] Carleton TA (2017) Crop-damaging temperatures increase suicide rates in India. Proc Natl Acad Sci USA 114:8746–8751.
- [7] Cohn EG et al. (2004). "Temperature, city size, and the southern subculture of violence: Support for Social Escape/Avoidance (SEA) theory". J Appl Soc Psychol. 2004; 34:1652–74.
- [8] Crimmins, A.; Balbus, J.; Gamble, J.L.; et al., eds. (2016). The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment (Report). Washington, DC: U.S. Global Change Research Program. Doi:10.7930/J0R49NQX. ISBN 978-0-16-093241-0
- [9] David, Heitz. (2018): "Research Shows Link Between Heats, Mental Illness Environmental Temperature". JAMA.1941; 116(6):474-477.
- [10] Haertzen C, et al (1993). Seasonal changes in rule infractions among prisoners: A preliminary test of the temperature-aggression hypothesis. Psychol Rep. 1993; 72:195–200. [PubMed]

- [11] Hanigan I.C et al (2012): "Suicide and drought in New South Wales, Australia, 1970–2007. *Proc Natl Acad Sci USA* 109:13950–13955
- [12] Hunsen A et al (2008): "The Effects of Heat waves on Mental Health in Temperate Australian city. *Environmental Health Perspectives*. 2008 116(10):1369-75. Doi: 10.1289/ehp.11339 PMID: 18941580 hyper polarizations in neocortical pyramidal neurons. *J Neurophysiol*. 2005 Apr; 93(4):2012-20.
- [13] Juanita Constible (2017): "Extreme Heat Takes a Toll on our Mental Health
- [14] Jull P (1991): "The Politics of Northern Frontiers in Australia, Canada, and Other 'First World' Countries: A Discussion Paper, North Australian Research Unit, Australian National University, Darwin, Australia. *J Physiol*. 1965 Dec; 181(3):656-70
- [15] Lin HC et al. (2008). "Seasonality and climatic associations with violent and nonviolent suicide: A population-based study. *Neuropsychobiology*. 2008; 57:32–7. [PubMed]
- [16] Linkowski P et al. (1992). "Effect of some climatic factors on violent and non-violent suicides in Belgium". *J Affect Disord*. 1992; 25:161–6. [PubMed]
- [17] Maes M et al (1994): "Synchronized annual rhythms in violent suicide rate, ambient temperature and the light-dark span". *Acta Psychiatr Scand*. 1994; 90:391–6. [PubMed]
- [18] McCoy J.M (2005): "Physical work Environment. In J. Barling, E.K. Kellowa & M. Frone Eds. *Handbook of Work Stress* (pp. 219-245). Thousand Oaks, CA: Sage Publication.
- [19] Morrissey S. A (1995): "Seasonal affective disorder: characteristics and prevalence in North Queensland [Ph.D. thesis], James Cook University of North Queensland, Townsville, Australia
- [20] Nick O et al (2018): *Emperical Evidence of Mental Health Risks Posed by Climate Change: Proceedings of the National Academy of Science of United States of America*.
- [21] Nick O et al (2018): *Emperical Evidence of Mental Health Risks Posed by Climate Change: Proceedings of the National Academy of Science of United States of America*.
- [22] Nick, O. (2018): *Empirical Evidence of Mental Health Risks Posed by Climate Change Nigeria Psychiatric Patients and their families*". *Psychiatric services* 63(6)
- [23] Nick, O. (2018): *Empirical Evidence of Mental Health Risks Posed by Climate Change Nigeria Psychiatric Patients and their families*". *Psychiatric services* 63(6)
- [24] Obradovich, N. (2017): "Nighttime temperature and human sleep loss in a changing climate". *Sci Adv* 3:e1601555.
- [25] Robin (2018) *Climate change and health*
- [26] Ruzek J.I (2004): "Integration of disaster mental health services with emergency medicine," *Pre-hospital and Disaster Medicine*, vol. 19, no. 1, pp. 46–53, View at Google Scholar • View at Scopus
- [27] Steadman R. G (1979): *The Assessment of Sultriness. Part 1: A Temperature-Humidity Index Based on Human Physiology and Clothing Science: Journal of Applied Meteorology* 18(7): 861-873 July 1979.
- [28] Wang X et al (2014): "Acute impacts of extreme temperature exposure on emergency room admissions related to mental and behavior disorders in Toronto", Canada. *J Affective Disord* 155:154–161.